CLAIMS

1. A package for an aqueous liquid wherein the package has a wall comprising an oxygen-scavenging polymeric composition, a thickness of the wall adapted to achieve oxygen removal from the liquid.

2. The package of claim 1, wherein the wall comprises a multi-layer including at least one layer of the oxygen-scavenging composition.

3. The package of claim 1, wherein the oxygen-scavenging composition comprises a polyamide and cobalt present in an amount of at least 200 ppm in the polyamide.

4. The package of claim 3, wherein the polyamide is a solid-stated polyamide.

5. The package of claim 4, wherein the polyamide is MXD-6.

6. The package of claim 2, wherein the oxygen-scavenging layer is positioned adjacent one or more layers of a polymer providing at least one of structural and oxygen barrier properties.

7. The package of claim 6, wherein the oxygen-scavenging layer is positioned between layers of the polymer.

8. The package of claim 6, wherein the polymer is biaxially-oriented.

9. The package of claim 8, wherein the polymer is selected from the group consisting of polyesters and polyolefins.

10. The package of claim 9, wherein the polymer is a polyester.

11. The package of claim 10, wherein the polymer is polyethylene terephthalate.

12. The package of claim 6, wherein the adjacent polymer layer is an inner layer, at least a portion of which is contacted with the aqueous liquid.

13. The package of claim 6, wherein the package includes at least a portion having two oxygen-scavenging layers positioned between three adjacent polymer layers.

14. The package of claim 1, wherein the aqueous liquid is beer.

15. The package of claim 1, wherein the wall is transparent.

16. The package of claim 15, wherein the wall has a percent haze of less than 10%.

17. The package of claim 15, wherein the wall has a percent haze of less than 7%.

18. The package of claim 15, wherein the wall has a percent haze of less than 5%.

19. The package of claim 2, wherein the multi-layer has an odd number of layers.

20. The package of claim 1, wherein the package, when filled with an aqueous liquid having a 100 ppb oxygen content, removes oxygen from the liquid.

21. The package of claim 20, wherein after filling with the aqueous liquid the package maintains an oxygen content below 100 ppb for at least 3 months.

22. A multi-layer package for enclosing an aqueous liquid having an oxygen content, the package comprising:

at least one oxygen-scavenging layer comprising a polyamide and cobalt in an amount of at least 200 ppm in the polyamide and wherein the package enclosing the liquid has an oxygen-removal rate greater than an oxygen-removal rate of a dry package.

23. A multi-layer composition comprising:

an oxygen-scavenging layer comprising a polyamide and cobalt in an amount of at least 200 ppm in the polyamide; and

a structural polymer layer positioned adjacent the oxygen-scavenging layer, wherein the structural layer is permeable to water.

24. A method of removing oxygen from an aqueous liquid having an oxygen content comprising:

providing a package having a wall comprising at least one oxygen-scavenging layer comprising a polymeric composition; and

selecting a thickness of the wall to achieve a reduction in the oxygen content.

25. The method of claim 24, wherein the oxygen content is reduced over a period of at least 3 months.

26. The method of claim 24, wherein the thickness selected enables reduction of an initial oxygen content of 100 ppb to a concentration of less than 50 ppb.

27. The method of claim 26, wherein the reduction in oxygen content begins within 2 days.

28. The method of claim 24, wherein the oxygen content is reduced at a rate of at least 50 ppb/day.

29. The method of claim 24, wherein the oxygen content is reduced at a rate of at least 150 ppb/day.

30. A method of reducing the oxygen content of a volume of a liquid comprising:

providing a sealed multi-layer container containing a volume of liquid, the container comprising at least one oxygen-scavenging layer, the at least one oxygen-scavenging layer comprising a polymer and cobalt, the polymer having a repeat unit including a carbonyl and at least one hydrogen atom alpha to the carbonyl, the cobalt being present in an amount of at least 200 ppm in the layer, and at least one structural polymer layer positioned between the at least one oxygen-scavenging layer and the volume of the liquid, wherein the oxygen content of the volume of the liquid in the sealed multi-layer container is maintained for a period of time below the oxygen content of a same volume of the liquid stored in a sealed glass container for the same period of time.

31. The method of claim 30, wherein the period of time is at least three months.

32. The method of claim 30, wherein the period of time is at least six months.

33. A method of reducing an oxygen content of a liquid in a multilayer container comprising:

the multi-layer container having a transparent sidewall portion, the sidewall portion including an oxygen-scavenging layer of a polyamide and cobalt in an amount of at least 200 ppm and a structural polymer layer positioned between the scavenging layer and the liquid; and

allowing a component of the liquid to permeate the structural layer to contact the scavenging layer and cause a reduction in oxygen content of the liquid.

34. The method of claim 33, wherein the inner structural layer is permeable to the component, the component being selected from the group consisting of water, carbon dioxide, nitrogen, volatile organic compounds, low molecular weight oligomers and trace impurities.

35. The method of claim 33, wherein the component is water.

36. A method of enhancing the oxygen-scavenging capability of an oxygen-scavenging composition comprising:

solid-stating a polyamide; and

adding cobalt to the polyamide in an amount of at least 200 ppm in the polyamide.

37. The method of claim 36, wherein the solid-stating comprises heating the polyamide under a low oxygen content atmosphere.

38. The method of claim 37, wherein the heating step comprises heating the polymer to a temperature above a glass transition temperature of the polymer and below a melting temperature of the polymer.

39. The method of claim 38, wherein the polymer is a polyamide and the heating step comprises heating the polyamide to a temperature of no greater than 210°C.

40. The method of claim 39, wherein the heating step comprises heating the polyamide to a temperature between 150°C and 210°C.

41. The method of claim 37, wherein the heating step is performed for at least four hours.

42. The method of claim 37, wherein the heating step is performed for at least eight hours.

43. The method of claim 37, wherein the heating step is performed for at least about 24 hours.

44. The method of claim 37, wherein the heating step is performed for at least 48 hours.

45. The method of claim 37, wherein the low oxygen content atmosphere is selected from the group consisting of an inert gas atmosphere and a reduced pressure atmosphere.

46. The method of claim 45, wherein the low oxygen content atmosphere is an inert gas atmosphere and the inert gas is selected from the group consisting of nitrogen and argon.

47. The method of claim 45, wherein the low oxygen content atmosphere is a reduced pressure atmosphere at a pressure of no greater than 15 torr.

48. The method of claim 47, wherein the  pressure is no greater than 10 torr.

49. The method of claim 47, wherein the pressure is no greater than 1 torr.

50. The method of claim 47, wherein the pressure is no greater than 0.1 torr.

51. The method of claim 37, wherein the heating step increases an intrinsic viscosity of the polymer.

52. The method of claim 51, wherein the polymer is MXD-6 and the intrinsic viscosity is increased to avalue of from 1.7 to 2.0.

53. The method of claim 51, wherein the polymer is MXD-6 and the intrinsic viscosity is increased to a value of from 1.75 to 1.9.

54. The method of claim 51, wherein the polymer is MXD-6 and the intrinsic viscosity is increased to a value of from 1.80 to 1.86.

55. A method for reducing a melt index of a polyamide, comprising:

adding a metal to the polyamide to achieve the reduced melt index and forming the polyamide in a layer structure with other polymers.

56. A method of making a multi-layer oxygen-scavenging article comprising:

providing a layer of an oxygen scavenger including a polyamide and a metal, and a layer of a structural polymer; and

adjusting a melt index of the scavenger compatible with a melt index of the structural polymer.

57. The method of claim 56, wherein the melt index of the scavenger is adjusted to a value of from 10g/10min. to 15g/10min.

58. A method for making a transparent multi-layer article having an oxygen-scavenging layer, comprising:

heating a polyamide under a low oxygen content atmosphere to increase the oxygen-scavenging performance of the polyamide with a given metal content by a factor of at least 1.3; and

forming the multi-layer article including at least one oxygen-scavenging layer formed of the polyamide and metal.

59. The method of claim 58, wherein the metal is cobalt.

60. The method of claim 59, wherein the cobalt is added to the polyamide as a cobalt compound.

61. The method of claim 60, wherein the cobalt compound is a solid selected from the group consisting of pellets, pastilles, crystals and powders.

62. The method of claim 61, wherein the cobalt compound is a cobalt carboxylate.

63. The method of claim 62, wherein the cobalt carboxylate is cobalt neodecanoate.

64. The method of claim 58, wherein the forming includes the step of positioning adjacent the at least one oxygen-scavenging layer and a layer of a polymer having at least one of structural and oxygen barrier properties.

65. The method of claim 64, wherein the forming step includes the step of providing compatible melt index values of the oxygen-scavenging layer and the polymer layer.

66. The method of claim 65, wherein the forming step includes the step of providing a melt index of the oxygen-scavenging layer lower than a melt index of the structural polymer layer.

67. The method of claim 58, wherein the article is a preform and the forming step comprises injecting the polymers into a mold.

68. The method of claim 58, wherein the forming step comprises coextruding the layers into a multi-layer sheet.

69. The method of claim 58, further comprising the step of biaxially stretching the multi-layer article.

70. The article of claim 58, wherein the article is selected from the group consisting of a container for food, a preform for a bottle and a cling film for wrapping food.

71. An injection-molded multi-layer preform for making a multi-layer oxygen-scavenging container having a transparent sidewall, the preform comprising:

a neck finish, a sidewall-forming portion and a base-forming portion;

the preform having at least one layer of an oxygen scavenger comprising a polyamide and cobalt in an amount of at least 200 ppm in the polymer; and

the scavenger having a substantially uniform thickness of the scavenging layer in the sidewall-forming portion.

72. A method of making an injection molded preform for a multi-layer oxygen-scavenging container having a transparent sidewall, wherein the preform includes a sidewall-forming portion having at least one oxygen-scavenging layer including a polyamide and cobalt to provide the scavenging function, the method including adjusting a melt index of the polyamide to provide a substantially uniform scavenging layer in the sidewall-forming portion of the preform.

73. A method for enhancing the oxygen-scavenging performance of a polyamide, comprising heating the polyamide, and wherein a plaque formed of the heat-treated polyamide has a greater oxygen-removal rate when exposed to moisture than when not exposed to moisture.

74. A transparent multilayer bottle for packaging an aqueous liquid containing oxygen having a wall comprising an inner layer or layers of an oxygen-scavenging composition having an activity on a wet plaque test of reducing an oxygen content from 21% to 19% or less in 54 days.

75. A composition for use as an oxygen scavenger which comprises a xylidene-substituted polyamide which has been treated so that the ratio of wet to dry plaque tests when the polyamide is mixed with 500ppm of cobalt is greater then 2:1.

76. A transparent multilayer bottle for packaging an aqueous liquid containing oxygen and comprising an inner layer or layers of an oxygen-scavenging composition and the inner layer or layers being between outer layers of a structural polymer or polymers and wherein the oxygen-scavenging performance as measured on the acqueous liquid filled bottle is greater then the scavenging rate measured on the unfilled bottle.

77. A xylidene-substituted polyamide for use as an oxygen scavenger which has been treated under solid-stating conditions and mixed with from 250 to 850ppm of cobalt.

78. A transparent multilayer bottle for beer comprising two inner layers of xylidene-substituted polyamide and 250 to 850ppm of cobalt, and a core layer and two outer layers of biaxially-oriented PET, where the thickness of each of the polyamide layers is in the range of 0.00254 to 0.00254mm and the thickness of each core and each outer layer is in the range of 0.0254 to 0.0508mm.

79. A container for enclosing an aqueous liquid, the container having a wall wherein the wall comprises at least one layer of a solid-stated polymer having a repeat unit containing a carbonyl, the polymer containing at least 200 ppm of a transition metal.

80. A container for enclosing an aqueous liquid, the container having a wall wherein the wall comprises at least one layer of a solid-stated polymer having a repeat unit containing a carbonyl, wherein the wall has a haze of less than 10%.

81. A container for enclosing an aqueous liquid, the container having a wall wherein the wall comprises at least one layer of a polymer having a repeat unit containing a carbonyl, the polymer containing at least 200 ppm of a transition metal, wherein the wall has a haze of less than 10%.

82. A container for enclosing an aqueous liquid, the container having a wall wherein the wall comprises at least one layer of a solid-stated polymer having a repeat unit containing a carbonyl, the polymer containing at least 200 ppm of a transition metal, wherein the wall has a haze of less than 10%.